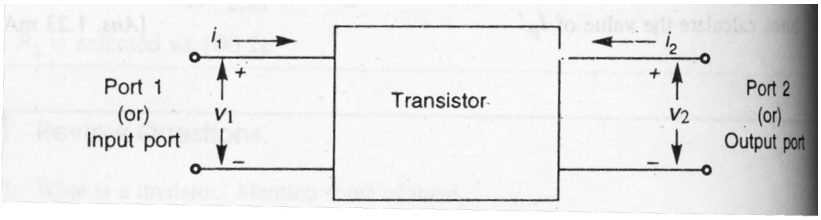
H – Parameter model:-

The equivalent circuit of a transistor can be dram using simple approximation by retaining its essential features. These equivalent circuits will aid in analyzing transistor circuits easily and rapidly.

Two port devices & Network Parameters:-

A transistor can be treated as a two part network. The terminal behavior of any two part network can be specified by the terminal voltages V_1 & V_2 at parts 1 & 2 respectively and current i_1 and i_2, entering parts 1 & 2, respectively, as shown in figure.



Two port network

Of these four variables V_1, V_2, i_1 and i_2, two can be selected as independent variables and the remaining two can be expressed in terms of these independent variables. This leads to various two part parameters out of which the following three are more important.

1. Z – Parameters (or) Impedance parameters
2. Y – Parameters (or) Admittance parameters
3. H – Parameters (or) Hybrid parameters.

Hybrid parameters (or) h – parameters:-

→ If the input current i_1 and output Voltage V_2 are takes as independent variables, the input voltage V_1 and output current i_2 can be written as

$$V_1 = h_{11}\, i_1 + h_{12}\, V_2$$
$$i_2 = h_{21}\, i_1 + h_{22}\, V_2$$

The four hybrid parameters h_{11}, h_{12}, h_{21} and h_{22} are defined as follows.

$h_{11} = [V_1 / i_1]$ with $V_2 = 0$

= Input Impedance with output part short circuited.

$h_{22} = [i_2 / V_2]$ with $i_1 = 0$

= Output admittance with input part open circuited.

$h_{12} = [V_1 / V_2]$ with $i_1 = 0$

= reverse voltage transfer ratio with input part open circuited.

$h_{21} = [i_2 / i_1]$ with $V_2 = 0$

= Forward current gain with output part short circuited.

The dimensions of h – parameters are as follows:

h_{11} - Ω
h_{22} – mhos
h12, h21 – dimension less.

→ as the dimensions are not alike, (ie) they are hybrid in nature, and these parameters are called as hybrid parameters.

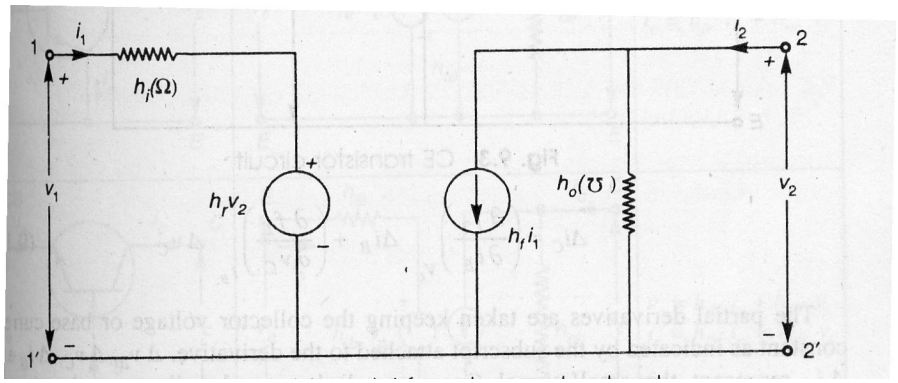
I = 11 = input ; 0 = 22 = output ;
F = 21 = forward transfer ; r = 12 = Reverse transfer.

Notations used in transistor circuits:-

$h_{ie} = h_{11e}$ = Short circuit input impedance
$h_{0e} = h_{22e}$ = Open circuit output admittance
$h_{re} = h_{12e}$ = Open circuit reverse voltage transfer ratio
$h_{fe} = h_{21e}$ = Short circuit forward current Gain.

The Hybrid Model for Two-port Network:-

$$V_1 = h_{11}\, i_1 + h_{12}\, V_2$$
$$I_2 = h_1\, i_1 + h_{22}\, V_2$$
$$\downarrow$$
$$V_1 = h_1\, i_1 + h_r\, V_2$$
$$I_2 = h_f\, i_1 + h_0\, V_2$$

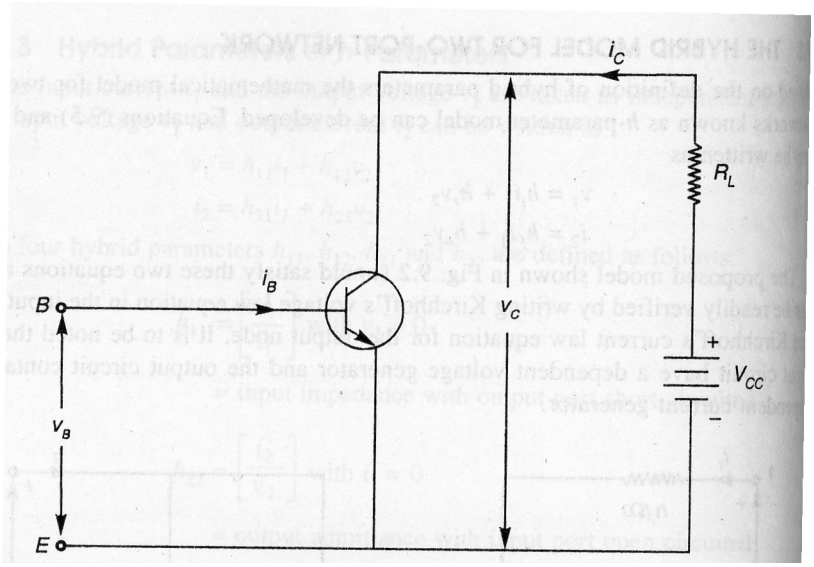


The Hybrid Model for Two-port Network

Transistor Hybrid model:-

Use of h – parameters to describe a transistor has the following advantages.

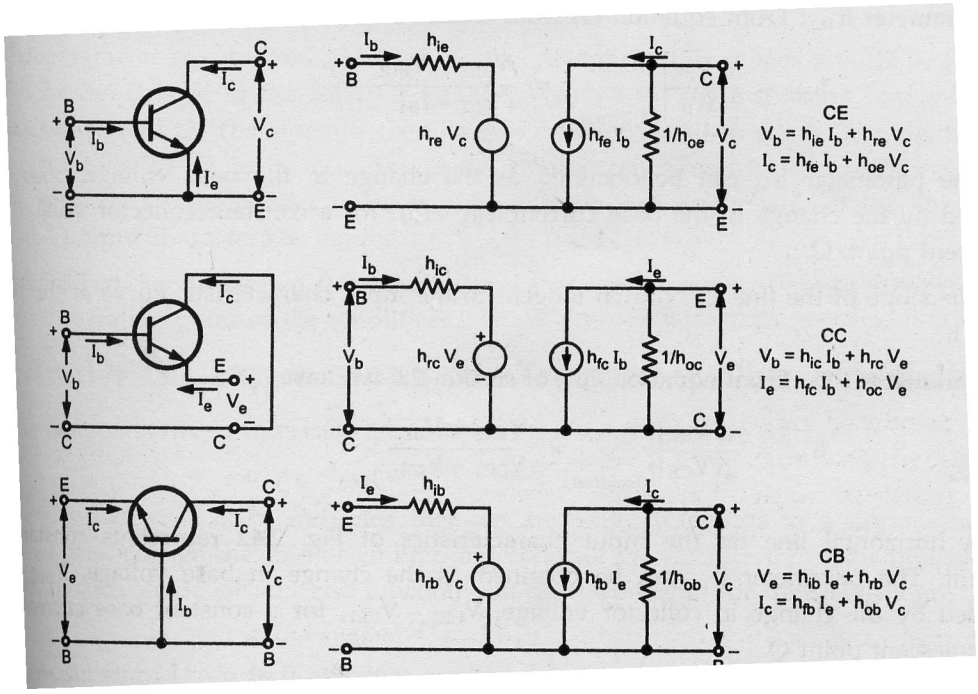
1. h – Parameters are real numbers up to radio frequencies.
2. They are easy to measure
3. They can be determined from the transistor static characteristics curves.
4. They are convenient to use in circuit analysis and design.
5. Easily convert able from one configuration to other.
6. Readily supplied by manufactories.



CE Transistor Circuit

To Derive the Hybrid model for transistor consider the CE circuit shown in figure.The variables are $i_{B,}$ i_c, $v_{B(=}v_{BE)}$ and $v_{c(=}v_{CE).}$ i_B and v_c are considered as independent variables.

Then, $v_B = f_1(i_{B,}\ v_c)$ ----------(1)
$i_C = f_2(i_{B,}\ v_c)$ ----------(2)



Why h-Parameters are used?

What is the reason for using h-parameters when describing transistors? Why are they used instead of the physical description?

ANS

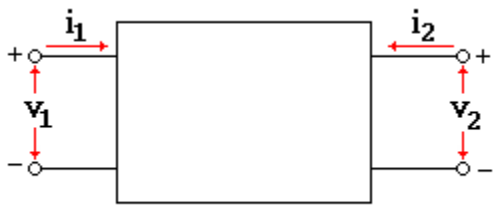
You don't use h-parameters instead of a transistor. H-parameters are one system for characterizing bipolar transistors. The h-parameters of a transistor will give you a good idea what it can do, how to use it effectively in a circuit, and whether it is appropriate for a particular circuit.

In practice, only a few h-parameters are commonly used. The most common one if hfe, which stands for h-forward-emitter. That means it is the ratio of output to input in the common emitter configuration, which in turn means it is the ratio of collector current to base current, which is basically the gain of a bipolar transistor. Beta is another similar but not completely identical measure of gain, although in most cases the two can be used interchangeably since a good circuit doesn't rely on exact values of gain anyway.

Sometimes you might see hre (h-reverse-emitter) which is a measure of how good a current source the transistor is at a particular fixed base current.

There are more h-parameters, but they get increasingly obscure and less commonly used.

A transistor (or many other kinds of analog circuits) can be considered as a two-port network, or quadripole. That means a block where the internal circuitry is not necessarily known, but is known the relationships between voltage and current at its ports.
So, you have a quadripole. You can draw it this way:



To describe the relationships between the four magnitudes, you need two equations of two variables, composing a square matrix. Depending on how the equations and the variables are arranged, the coefficients can be different magnitudes, and in this case:

- A dimensional: voltage over voltage, current over current
- Impedance: voltage over current
- Admittance: current over voltage

You can arrange the equations to have only impedances (z-parameters), only admittances (y-parameters) or a mix of them. This is the case of the

hybrid parameters (h), where V_1 and I_2 are expressed as functions of V_2 and I_1. This leads to four h-parameters, specifically:

- $h_{11} = h_i = v_1 i_1 \big|\big|_{v_2=0}$
- $h_{12} = h_r = v_1 v_2 \big|\big|_{i_1=0}$
- $h_{11} = h_f = i_2 i_1 \big|\big|_{v_2=0}$
- $h_{11} = h_0 = i_2 v_2 \big|\big|_{i_1=0}$

Therefore h_{fe} represents the h-parameter that describes the forward current gain in the common-emitter configuration, or commonly the current gain of the transistor.

In my point of view h-parameters are used for small signal frequency analysis, it knows system performance by calculating the out put, gain .it has one disadvantage: it can't suitable for large signal amplification. In this model input voltages and output current are dependent.